## EEDI Won't Work

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The International Maritime Organization (IMO) may be on the verge of enacting an amendment to MARPOL which would require new large ships to meet an Energy Efficiency Design Index (EEDI). EEDI is a calm water, trial measurement of the CO2 output of the ship at a *single* power rating (75% MCR) ratioed to a measure of the ship's transport capability. The assumption is that a 25% reduction in EEDI will result in a 25% reduction in fleet CO2 emissions. This claim was central to the IMO's recent report to the Cancun Conference. And it is just flat wrong.

EEDI is based on a static view of the world. The basic fallacy underlying EEDI is that the ship's steaming speed is fixed. In competitive sectors such as tankers, bulk carriers, and the de-cartelized container trades this will happen only if the market spot rate is constant.

In fact, in the bulk trades, the spot rate ranges from rates so low that the owner is barely covering his fuel bill to rates so high that the owner can pay off a ship in as little as ten voyages. Figure 1 shows the VLCC spot rate for the last 20 years. The basic pattern is longish periods of very low rates, during which, at current and projected BFO prices, the ships will be steaming as slow as they can, interspersed with spikes in which the ships will steam as fast they can, almost regardless of bunker price. The ships will almost never be steaming at 75% MCR.

Figure 2 is a histogram of VLCC spot rates over the last 20 years. The average of these spot rates, Worldscale 63, is roughly equal to the rate the VLCC owner would have to average in order to just breakeven on his investment including cost of capital, the so-called RFR. However, 90% of the time, rates are below RFR, usually well below. Less than 10% of the time, the rate is in full scale boom, several times RFR.

In order to properly analyse EEDI, or a carbon dumping fee, or mandatory max speed or any other regulation which affects steaming speed, we must do so over a market cycle adjusting the ship's speed to the current spot rate. CTX has undertaken such a study using VLCC's as an example.

The study compared an EEDI-compliant and a non-EEDI compliant (no regulation) VLCC for two BFO prices

1. \$465 (about current)

2. 620 (current plus 50/t CO2 dumping fee)<sup>1</sup> and three EEDI levels: Phase I (-10% from baseline), Phase II (-25%), Phase III (-35%) Both ships incorporated feasible, prudent, efficiency measures which currently have negative abatement cost. See The Impact of EEDI on VLCC Design and CO2 Emissions. for the full story.

Table 1 shows typical results.

Table 1. Phase 1 Percent Reduction in CO2, BASE(no EEDI) vs 6 cyl ship (EEDI). BFO=\$465

LEDI	) vs o cyr sing	$(\mathbf{D}\mathbf{D}\mathbf{D}\mathbf{I})$ .	DI O = 040	0
WS	Avespd	Avespd	Ratio	%
	Non-EEDI	EEDI	CO2	Diff.
30	10.25	10.25	1.0000	-0.0
40	10.74	10.74	1.0000	-0.0
50	11.19	11.19	1.0000	-0.0
60	11.97	11.97	1.0000	-0.0
70	13.20	13.20	1.0000	-0.0
80	14.24	14.00	0.9820	-1.8
90	15.00	14.75	0.9846	-1.5
100	15.49	15.25	0.9948	-0.5
110	15.99	15.49	0.9732	-2.7
120	16.25	15.94	0.9903	-1.0
130	16.49	15.94	0.9747	-2.5
140	16.72	16.17	0.9762	-2.4
150	16.83	16.17	0.9632	-3.7
160	16.83	16.17	0.9632	-3.7
170	16.83	16.17	0.9632	-3.7
180	16.83	16.17	0.9632	-3.7
190	16.83	16.17	0.9632	-3.7
200	16.97	16.17	0.9427	-5.7
Average	1.238	1.226		-1.0

In Table 1, the second and third columns were computed by finding the loaded/ballast speed that maximizes the owner's \$/day earnings for the given spot rate, fuel cost, and speed/fuel curve. (The optimization was done in half knot increments, so it can a little jumpy.) The fourth column was generated by computing how much CO2 each ship would produce per ton per day delivered on the standard route (in this case Ras Tanura-Yokohama), and then ratioing these two numbers. In other words, the fleet sizes have been adjusted to deliver the same amount of

 $^1$  A ship emits a little over 3 tons of CO2 per ton of fuel burned. A \$50/t CO2 fee imposed as a bunkers tax would increase the owner's fuel cost roughly \$150/t BFO.

transport capacity. The bottom line shows the CO2 produced per ton of cargo delivered per day for each ship averaged over the market cycle using Figure 2. In this case, the Phase I EEDI compliant fleet produces 1% less CO2 over the market cycle.

Table 2 summarizes the results

Table 2. Overall Summary of Results Pct reduction in CO2 Emissions averaged over market cycle Negative implies EEDI compliant fleet better. BFO Phase 1 Phase 2 Phase 3

DFO	I hase I	I mase 2	I mase 0
COST			
\$465	-1.0%	+0.5%	+1.1%
\$620	-0.5%	-0.2%	+1.4%

The Phase 2 and Phase 3 EEDI fleet produce **more** CO2 than the non-regulated fleet. How can this be? The answer is two fold:

- 1. EEDI effectively limits installed power. But at current and expected BFO prices, a non-EEDI VLCC owner uses all his installed power only in a full boom. So for the great bulk of her life, a non-EEDI ship uses little or no more power than an EEDI-compliant ship.
- 2. In limiting installed power, EEDI induces owners to use smaller bore, higher RPM engines. Table 3 shows CTX's estimate of how VLCC owners will respond to EEDI. These engines have higher Specific Fuel Consumption and more importantly require a smaller, less efficient propeller. This means the EEDIcompliant VLCC consumes more fuel when the market is not in boom, which is 90% of the time.

Even if we unrealistically assume away problem (2), our numbers indicate that the Phase 2 (25% reduction in EEDI) EEDI-compliant VLCC fleet will produce about 2% less at-sea CO2 than the non-EEDI fleet. And this is only at-sea emissions. Table 4 shows the VLCC fleet size requirements of EEDI.

Table 4.	Increase in	Fleet Size	for same	transport capacity	y
		Phase 1	Phase 2	2 Phase 3	
	Fleet Size	+4%	+18%	-+32%	
В	/R/S CO2	+0.1%	+0.6%	6 +1.1%	

The increase in Build/Repair/Scrap emissions is based on Gratsos et al converted to equivalent atsea emissions.<sup>2</sup> Gratsos considered only emissions at building, repair and breaking yards. Mining, flying crews around, additional cargo loss due to tank breathing, etc were not included.

Finally, these are all calm water numbers. The low-powered EEDI compliant ship will have considerably poorer performance in heavy weather than the non-EEDI ship. As Table 3 shows, in order to meet Phase 3 EEDI, VLCC's will have to go down to about 13,000 KW MCR. This is less than half present practice. This ship will not only have great difficulty maintaining any speed in bad weather, but also her engine will be pushed much harder over the market cycle than the non-EEDI ship's. And that means a big jump in machinery failures.

As far as I know, similar studies have not been done for smaller tankers, bulkers, or big containerships; but there is every reason to believe that such studies would generate very similar results.

EEDI is a loser. So what should we do? The answer will be obvious to any first year economics student: charge the polluter for his pollution. Table 5 shows how VLCC owners would respond to a \$50 per ton CO2 dumping fee which would increase the owner's BFO cost about \$150/t.

Table 5. Percent Reduction CO2, \$50/ton CO2 fee Non-EEDI ship at \$465 versus \$620 BFO cost

Non-EED	I ship at	\$465 versus	\$620 BF	O cost
WS	Avespd	Avespd	Ratio	%
	465	620	CO2	Diff.
30	10.25	9.98	0.9854	-1.5
40	10.74	9.98	0.9472	-5.3
50	11.19	10.50	0.9307	-6.9
60	11.97	10.74	0.9197	-8.0
70	13.20	11.74	0.8965	-10.4
80	14.24	12.24	0.8865	-11.3
90	15.00	13.24	0.9094	-9.1
100	15.49	14.00	0.9224	-7.8
110	15.99	14.50	0.9141	-8.6
120	16.25	15.25	0.9301	-7.0
130	16.49	15.49	0.9262	-7.4
140	16.72	15.75	0.9290	-7.1
150	16.83	15.99	0.9297	-7.0
160	16.83	16.49	0.9678	-3.2
170	16.83	16.49	0.9678	-3.2
180	16.83	16.72	0.9867	0.0
190	16.83	16.72	0.9867	0.0
200	16.97	16.83	0.9787	-2.1
				-2.1
260	16.97	16.83	0.9787	-2.1
270	16.97	16.97	1.0000	-0.0
Average	1.238	1.161		-6.2

Over the market cycle, this carbon dumping fee would generate a 6.2% reduction in CO2, far more than any level of EEDI. But it is how the fee works that is interesting. Comparing Tables 1 and 5, below about WS150 — in other words, almost all the time — the non-EEDI ship with the fee is steaming **more slowly** than the Phase I EEDI compliant ship without the fee. It is only in an all-out, full boom that the non-EEDI ship with the fee steams faster than the Phase I EEDI ship without the fee. But this is exactly what we want, for it avoids wastefully expending resources on additional ships, just to handle a boom.<sup>3</sup>

A carbon dumping fee is effective, efficient, and safe. EEDI is none of the above.

<sup>&</sup>lt;sup>2</sup> Gratsos, G., Psaraftis, H. and Zachariadis, P., Life Cycle CO2 Emissions of Bulk Carriers: A Comparative Study, Int. Journal of Maritime Engineering, Jul-Sep 2010, pp A 119-A 134.

 $<sup>^{3}</sup>$  In economic jargon, the marginal societal value of a ton-knot of transport capacity is far higher in a boom than in a slump. A fee responds to this order of magnitude change in value efficiently. EEDI and other mandated restrictions do not.

Table 3. Main Propulsion Parameters of EEDI Compliant VLCC				
	No EEDI	Phase 1	Phase 2	Phase 3
g CO2/dwt-kt @75% MCR	2.54	2.09	1.74	1.51
MCR(kW)	$27,\!500$	$23,\!600$	$16,800^{*}$	13,200**
Number cylinders	7	6	6	6
BORE(mm)	840	840	650	600
RPM(MCR)	76	76	95	105
SFC @ MCR (book)	168	168	171	171
PROP DIAM.(m)	9.9	9.9	8.5	8.0
Propulsive Efficiency	0.730	0.734	0.682	0.647
Expanded Area Ratio	0.487	0.412	0.447	0.431
Trial Loaded Speed	16.5	15.5	13.6	12.4

- \*De-rated from 17,200 kW. \*\*De-rated from 14,400 kW.
- Dis-allowed less than 6 cylinders on vibration grounds. Reduction gear not considered.
- Lower powered ships spend much more of the market cycle at or close to MCR and above the min SFC point.
- Heavy weather, maneuvering characteristics of ships on right need to be carefully studied.
- Strength, cavitation, heavy weather performance of unprecedentedly narrow VLCC propeller blades need careful study.

